Transcutaneous electrical nerve stimulation and chronic intractable angina pectoris

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The treatment trial being reported investigated whether the frequency and severity of pain in 11 patients with chronic intractable angina pectoris were decreased by TENS applied adjacent to T_1 and T_5 spinous processes. Pulse and blood pressure were measured before, during and after each treatment. Results showed a significant decrease in frequency and severity of pain. Rate pressure product was calculated to try to identify the mode of action. The mean RPP before TENS application, compared with the mean RPP at 30 minutes and at 90 minutes, was significantly reduced. It was concluded from these results that TENS should be considered as an adjunct to medical management in those patients with angina pectoris not satisfactorily controlled by optimal medication.

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The term angina pectoris was first used by Heberden to describe the pain of cardiac origin (Procacci and Maresca 1985). Ischaemia has been identified as the cause of cardiac pain. It increases sensory nerve activity in the adventitia of coronary arteries, the myocardium and the subepicardial tissue. Metabolites associated with ischaemia may contribute to the stimulation of pain receptors. Sensory and pain afferent impulses from the heart are transmitted to the central nervous system via fibres in the cervical and thoracic sympathetic nerves. These reach the spinal cord via the upper four or five thoracic dorsal nerve roots (Mannheimer et al 1985, Procacci and Maresca 1985). This neurological input would account for the variable distribution of the pain perceived during episodes of angina pectoris. It has been postulated that the pain of angina pectoris may secondarily increase myocardial ischaemia by increasing sympathetic activity (Mannheimer et al 1982).

At some stage in the medical management of chronic intractable angina pectoris, optimal levels of medication no longer control the resting or exercise induced pain suffered by a number of patients. Often, these people have had coronary artery bypass surgery or have inoperable coronary artery disease. As a consequence, their life-style has become severely restricted and the frequency of hospital admissions is high.

Transcutaneous electrical nerve stimulation (TENS) has been in use for a number of decades for the management of pain. Its mode of action is still under investigation but it appears that variable stimulation modalities lead to a variety of neurological, histochemical and neuropharmacological responses (Gersh and Wolf 1985). When TENS is used to manage cardiac pain it not only works in the expected pain relieving manner, but also appears to suppress sympathetic activity (Mannheimer et al 1985, Procacci and Maresca 1985). To date, no studies have been undertaken to establish the effect of TENS on angina, which do not require the patient to perform work.

In an attempt to improve the quality of life in patients with chronic intractable angina pectoris, one of the cardiac physicians at Greenslopes Repatriation Hospital in Brisbane referred the first patient to the Physiotherapy Department for a trial of TENS to help control the angina. As no physiotherapist on the staff had used TENS for this purpose, current guidelines for TENS application and the nerve supply to the heart were considered in developing a treatment method as well as a need for accurate

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recording of the response to treatment. The clinical problem to be addressed was whether TENS could be used to reduce the disability caused by the pain and the frequency of occurrence of angina pectoris in the patients referred for treatment. The effect of treatment was assessed by comparing the intensity of pain and the frequency of angina attacks before and after a course of treatment. Also, blood pressure and heart rate were recorded before, during and after each treatment.

The treatment protocol and the method of assessing its effect were approved by the Medical Ethics Committee of Greenslopes Repatriation Hospital. All patients gave informed consent.

Method

Eleven patients referred for treatment were included in the trial and treated with TENS for chronic intractable angina pectoris which was not controlled by maximal tolerated medication dosage. All were experiencing pain at rest or on minimal exertion due to activities of daily living such as showering, dressing, toileting or eating. They were extremely limited in life-style and quite unable to participate in normal activities undertaken by people of similar age. Those patients referred for a trial of treatment who lived outside Brisbane were usually kept as inpatients until the trial was completed. Those patients resident in Brisbane attended as outpatients. Although the use of placebo TENS in a similar group of patients to compare results to those treated was considered, an increase in length of hospital stay or number of outpatient attendances for this placebo group would have been costly if they were then to also trial treatment of TENS.

To maintain maximal control of variables, the patients and medical staff cooperated to ensure there was no change in medication, diet or level of activity while the trial was under way. The same physiotherapist treated all

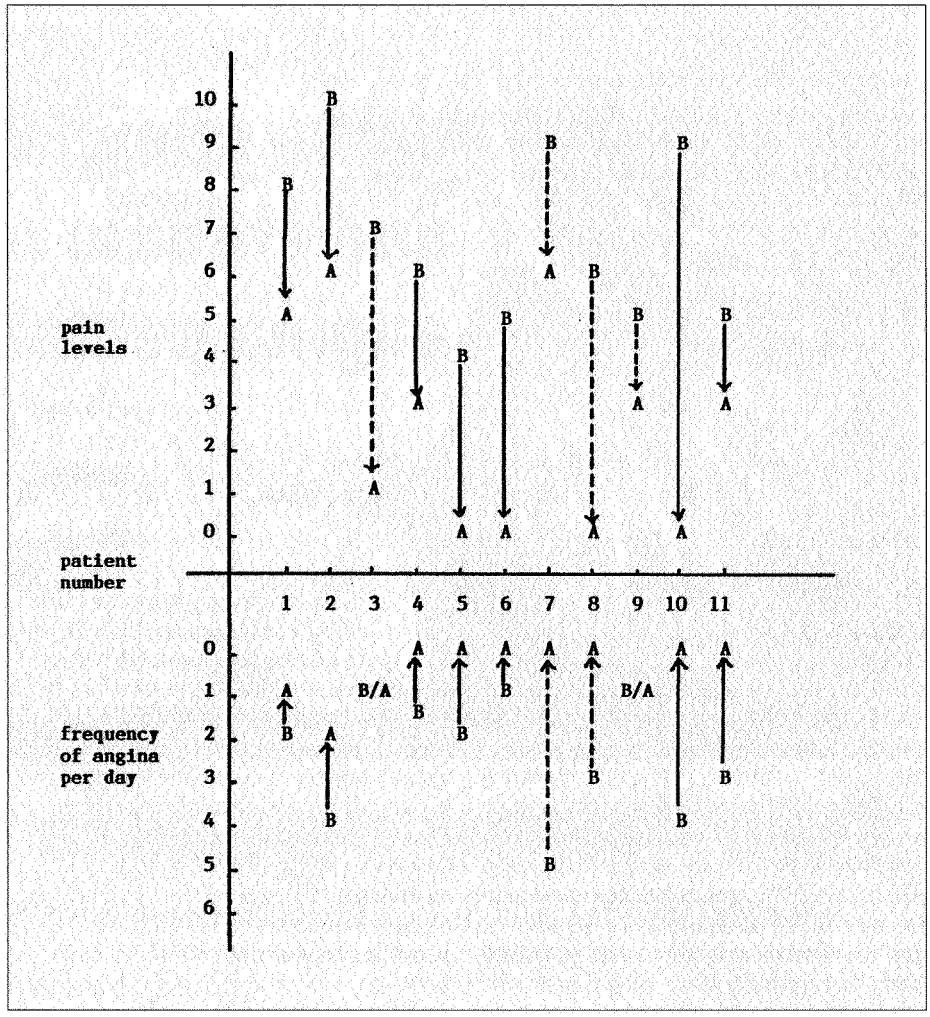

Figure 1.
Pain levels and frequency of angina before and after the trial of TENS.
A = after, B = before
_____ 2 treatments per day
_ _ _ _ _ _ _ 1 treatment per day

patients to eliminate interoperator error.

The apparatus used was a Neuromod dual channel TENS unit delivering a biphasic exponentially decaying spike wave form stimulation with zero DC component, and an 0.8msec pulse width at a rate of 85Hz. The stimulus was delivered by four carbonised rubber electrodes. Skin contact was maintained by electrode-conducting gel. All electrodes were secured in place with tape. The same mercury sphygmomanometer and stethoscope were used for each measurement of blood pressure for all patients undertaken by the same person.

Age, gender, diagnosis, past medical and surgical history, as well as current medication, were recorded for each patient. A short seven-response questionnaire indicating the patient's pain pattern was administered by the physiotherapist responsible for each treatment. This showed frequency of angina episodes, precipitating factors and how the patient coped with the pain. It also showed the anatomical site of most pain. At the same time, the patient marked the first visual analogue pain scale (Melzack 1987) to indicate the usual severity of pain.

Pulse and blood pressure were recorded prior to commencing treatment. The TENS electrodes were applied paraspinally adjacent to the spinous processes of the first and fifth thoracic vertebrae, one channel on each side. The intensity of the stimulation was turned up to a level perceived by the patient as comfortable. This amplitude was recorded on the patient information sheet and was kept constant throughout the 90 minute treatment time. Pulse and blood pressure were recorded 30 minutes after application and again when the TENS was turned off after 90 minutes. Each treatment was given at the same time each day, commencing at half past nine in the morning or half past one in the afternoon. Previous studies by Mannheimer et al (1982) reported using three one-hour sessions daily. However this was not practical in the present study, so 90 minute sessions were adopted.

The treatment was repeated twice daily for 10 sessions for inpatients, or once daily for outpatients, who also received 10 treatments. Where possible, the trial was started on Monday and continued on consecutive days except weekends. There were seven patients who received twice daily treatments. The remaining four received one treatment each day, either morning or afternoon depending on the work load of the treating physiotherapist. During the treatment, the patient was not required to perform any specific task, but some read or watched television. Toilet privileges were allowed during treatment.

Prior to the first treatment on subsequent days, the number of episodes of angina experienced during the previous 24 hours was recorded on the patient's data sheet. At the end of the tenth treatment session, a second visual analogue pain scale was completed.

Results

The 11 patients referred for treatment during the six-month trial period were all males and ranged in age from 67 to 81 years (average age 74.6 years). All were severely limited by angina in their ability to perform the normal activities of daily living. The complex medical picture seen in this age group was demonstrated by the questionnaire. Of the 11 patients, six had a history of myocardial infarction, five had arthritis, three had chronic obstructive airway disease, three had hypertension, one had atrial fibrillation, one had non-insulin dependent diabetes mellitus, one had a cerebrovascular accident and two had had coronary artery bypass surgery. Obviously, most patients had more than one medical problem. However, the disability due to the angina pectoris from ischaemic heart disease was the major factor limiting activity in all patients.

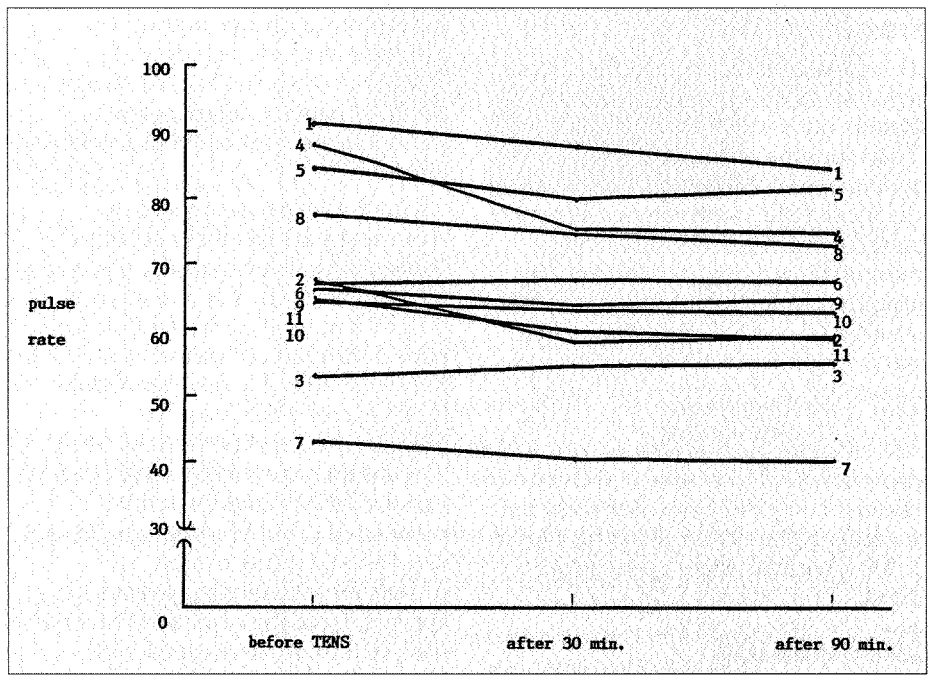

Figure 2.
Mean pulse rate before, during and after TENS application for subjects 1 to 11.

The average daily frequency of angina episodes prior to commencing treatment with TENS was compared with the average number of daily episodes at the end of the trial using a Wilcoxon test for paired observations. This showed a significant decrease in the number of episodes of angina during the trial ($p<0.01$). A paired t-test was used to compare the results from the visual analogue pain scales. A significant reduction in intensity of perceived pain was demonstrated ($t_{10} = 3.581$, $p<0.005$). For each patient, the change in pain levels and the average frequency of angina episodes each day prior to the trial and after the trial are demonstrated in Figure 1. There was no difference in response to the TENS treatment in those patients receiving one or two treatments per day except that those receiving two treatments generally showed marked reduction in the frequency of severity of angina by the third day. Those patients receiving one treatment a day usually took five days to show this response. However, this observation could not be verified statistically.

In an endeavour to determine how TENS achieved the reduction in pain and frequency of angina attacks, heart rate and blood pressure were measured before, during and after each treatment. Gobel et al (1987) and Kispert (1987) identified the rate pressure product (RPP), which is calculated from heart rate x systolic

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blood pressure as an easily measured indicator of haemodynamic variables, namely myocardial oxygen uptake. Therefore the mean RPP before application of TENS was compared to the mean RPP at 30 minutes using a paired *t*-test. This was significantly reduced ($t_{10} = 3.581$, $p<0.005$) at 30 minutes and further reduced after 90 minutes ($t_{10} = 4.587$, $p<0.001$). There was no significant difference between mean RPP at 30 minutes and mean RPP at 90 minutes. The mean pulse rate taken for each patient before, at 30 minutes into the treatment and after 90 minutes compiled from data collected at each treatment, are shown in Figure 2. Most patients show a downward trend.

Discussion

The results of this trial showed a very significant reduction in the frequency and severity of anginal episodes over the period of 10 treatment sessions. Subjectively, at least 50 per cent reduction in frequency of pain level was noted by the fifth or sixth treatment irrespective of whether the patients were having one or two treatments daily.

The 11 patients who participated were older (mean age 74.6 years) than those previously studied (Mannheimer et al 1982 and 1985, Murphy and Giles 1987).

In other investigations where TENS was used for patients with angina pectoris, the electrodes were positioned on the chest wall over the site of most intense pain (Mannheimer et al 1982 and 1985). The rationale for such electrode placement was for pain blocking with a presumed effect on sympathetic outflow. In the treatment trial reported here, the TENS electrodes were placed paraspinally at the level of T_1 and T_5 in an attempt to directly affect both the sensory input and the sympathetic output. This non-invasive placement of electrodes was based on a rationale similar to that reported by Murphy and Giles (1987) where dorsal column epidural stimulation was used to treat intractable angina pectoris. The resultant decrease in pain and frequency of angina in the present group of patients suggests that paraspinal positioning of electrodes is effective.

Stimulation parameters in this treatment trial and other reported studies were determined by the type of TENS unit used. The Neuromod TENS unit used in this trial had a pulsed stimulus of 0.8msec at a frequency of 85Hz compared with 0.2msec and 70Hz used by Mannheimer et al (1982 and 1985). The different parameters delivered by various TENS units should be considered if this treatment technique is to be used in the overall management of angina pectoris. It appears, from the results of this small trial, that these moderately high frequencies have a positive effect on the patient's experience of pain. Mannheimer et al (1990) reported that patients used high frequency TENS to avert angina in anticipated attacks but used low frequency TENS of the pulse train type stimulus for long term prevention. The present study used high frequency for the same effect with more comfort.

It appears that at least six consecutive treatments should be undertaken before deciding on the effectiveness of this form of management for an individual. Although the generalised decrease in pulse rate and rate pressure product during TENS treatment may be attributable to rest, the reduction in frequency and severity of angina may reflect an improvement in the relative ischaemic state of the heart. The RPP has been shown to be a valid indicator of myocardial oxygen uptake (Kispert 1987) for measures performed at rest. The results from this trial showed a highly significant reduction in RPP both at 30 and 90 minutes ($p<0.005$ and $p<0.001$). Mannheimer et al (1985) also showed a reduction in the RPP when subjects were at rest and using TENS. This lowering of RPP is similar to the effect seen after beta adrenergic blockade with propranalol (Gobel et al 1987) and upper thoracic sympathectomy (Mannheimer et al 1982). A more recent study by Mannheimer et al (1990), showed that the anti-ischaemic and anti-anginal effect of TENS may have been explained by reduced sympathetic activity since arterial levels of epinephrine and norepinephrine and systolic blood pressure decreased during TENS stimulation during exercise. A single high dose of naloxone, a drug which blocks the effect of endogenous opioids, also failed to stop the beneficial effects of TENS in their study, showing that the effect was not solely due to TENS stimulating endogenous opioid release. Mannheimer et al (1990) had postulated that they might be responsible for the TENS effect on angina. However, a non-opioid mechanism may be responsible for the anti-ischaemic and anti-anginal effect of TENS as shown by an improved myocardial lactate metabolism (Mannheimer et al 1990).

Although the results of this and other studies show that TENS is an effective treatment for chronic intractable angina pectoris, the mode of action of TENS on the heart is still obscure and ongoing research into its mode of action should be pursued.

This treatment trial provides an indication that TENS is an effective method of reducing the frequency and severity of anginal episodes in patients with chronic intractable angina pectoris. This modality, therefore, should be considered as an adjunct to medical management for those patients who are not satisfactorily controlled by optimal medication.

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